METHODS OF PACKAGING SEMICONDUCTOR WAFERS BY MOLDING A PACKING BAG ABOUT A CARRYING DEVICE THAT CONTAINS THE SEMICONDUCTOR WAFERS

Related Application

This application claims the benefit of Korean Patent Application No. 00-39556, filed July 11, 2000, the disclosure of which is hereby incorporated herein by reference.

Field of the Invention

The present invention relates generally to methods of packing semiconductor wafers, and, more particularly, to methods of packing semiconductor wafers using mechanical molding techniques.

Background of the Invention

Semiconductor wafers may be packed using packing materials that prevent and/or reduce contaminants, particles, and/or haze from accumulating on the wafer surfaces when the wafers are stored and/or transported. Typically, a cassette in which wafers are inserted is wrapped and sealed using packing materials. Various packing methods may use a vacuum or inject an inert gas when the cassette is sealed.

To prevent overstock and/or to maintain a balance between the supply and demand for semiconductor wafers, it may be necessary to store wafers in a packaged state after the wafers have been cleaned for relatively long periods of time such as, for example, about 45 days. In addition, packaged wafers may also spend relatively long periods of time in transport. It is generally well known that wafer surfaces may be damaged and/or degraded when packaged wafers are stored and/or transported for extended periods of time.

For example, contaminants such as SO_X or NO_X may be absorbed into the surface of a wafer and react with the silicon to form an undesired contaminative layer on the surface of the wafer. The contaminative layer may be a source of defects during semiconductor device manufacturing processes. The wafer may be cleaned in an attempt to remove the contaminative layer, but, in general, the contaminative layer is difficult to remove.

Furthermore, as semiconductor devices become larger and more highly-integrated, wafers having a larger caliber, such as a 300 mm wafer, may be used. Because of their increased size, the probability that a 300 mm wafer contains contaminants is generally greater than that of a conventional wafer having a smaller caliber.

Summary of the Invention

According to embodiments of the present invention, semiconductor wafers are packed by providing a carrying device that holds one or more semiconductor wafers. The carrying device is inserted into a packing bag and the packing bag is molded using at least a portion of the external form of the carrying device as a guide such that a portion of the packing bag substantially conforms to the portion of the external form of the carrying device. Thus, wafers may be packaged without using a vacuum while still inhibiting contamination from particles and the formation of haze on the surface of the wafers.

In accordance with further embodiments of the present invention, the packing bag described above may be a second packing bag and the carrying device may be inserted into a first packing bag before the carrying device is inserted into the second packing bag. The first and second packing bags may be a polypropylene bag and an aluminum bag, respectively.

In accordance with still further embodiments of the present invention, the first packing bag may be sealed such that the carrying device remains in communication with the environment external to the first packing bag. In particular embodiments, the first packing bag may be sealed by folding a portion of the first packing bag through which the carrying device was inserted.

In accordance with still further embodiments of the present invention, inserting the carrying device into the first packing bag, inserting the carrying device and the

first packing bag into the second packing bag, and molding the second packing bag may be performed in a packing room that is on a same level as a wafer cleaning room. Moreover, the semiconductor wafer(s) may be cleaned before inserting the carrying device into the first packing bag, inserting the carrying device and the first packing bag into the second packing bag, and molding the second packing bag.

In accordance with still further embodiments of the present invention, a portion of the second packing bag that does not substantially conform to the portion of the external form of the carrying device may be trimmed away.

Brief Description of the Drawings

Other features of the present invention will be more readily understood from the following detailed description of specific embodiments thereof when read in conjunction with the accompanying drawings, in which:

FIGS. 1 - 4 are perspective views that illustrate methods of packing wafers in accordance with embodiments of the present invention.

Detailed Description of Preferred Embodiments

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that there is no intent to limit the invention to the particular forms disclosed, but on the contrary, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the claims. Like numbers refer to like elements throughout the description of the figures.

According to embodiments of the present invention, wafers may be packed and/or stored so as to inhibit contamination from particles and to inhibit the formation of haze on the surface of the wafers. Rather than sealing wafers in a bag using a vacuum, embodiments of the present invention may use a "tight cut" methodology in which wafers carried in a cassette or carrying device are packaged in a packing bag.

Tight cut means that the packing bag is mechanically shaped and molded so as to cause an internal side of the packing bag to generally tightly adhere to an external form of the cassette, the packing bag is molded to seal the cassette, and an excess or unnecessary border of the packing bag is sleekly cut out when the packing bag is

sealed after the cassette is put into the packing bag. In accordance with embodiments of the present invention, wafers may be packaged in a packing bag without applying a vacuum to the packing bag.

FIG. 1 illustrates the placement of a cassette **100** carrying a wafer **105** into an inner packing bag **200**, which may be embodied as a polypropylene bag **200**. The wafer **105** may be a 300 mm wafer, which is used in semiconductor device manufacturing processes. Because of the large caliber of the wafer **105**, the potential for haze formation on the surface of the wafer and/or contamination of the wafer by particles may be relatively high. Typically, multiple wafers **105** are installed into the cassette **100** in units of about 13 sheets.

The cassette **100** in which the wafers **105** are inserted is put into a polypropylene bag **200** and packed. Occurrence of static electricity in the polypropylene bag **200** is typically low; thus, the polypropylene bag **200** generally has excellent electrical stability characteristics. The polypropylene bag **200** also has a generally high resistance to particle contamination and, therefore, may be used to inhibit particles from contaminating the surface of the wafers. In accordance with embodiments of the present invention, packing bags made of other contamination resistant materials may be used to implement the inner packing bag **200**.

The cassette **100** may be packed in the polypropylene bag **200** in a manner such that the polypropylene bag **200** fits loosely about the external form of the cassette **100**. In accordance with embodiments of the invention, the polypropylene bag **200** may be sealed such that the cassette **100** remains in communication with the environment external to the polypropylene bag **200**. That is the area internal to the sealed polypropylene bag **200** may spatially communicate with the area external to the polypropylene bag **200**. In particular embodiments of the present invention, an entrance portion of the polypropylene bag **200** is folded to seal the polypropylene bag **200**.

FIG. 2 illustrates the placement of the cassette **100** into an outer packing bag **300**, which may be embodied as an aluminum bag **300**. According to the embodiments of **FIG. 2**, the cassette **100**, which has been packed into the polypropylene bag **200**, is put into the aluminum outer packing bag **300**. The

aluminum bag **300** may protect the cassette **100** and/or the wafers **105** from the external environment.

FIG. 3 illustrates exemplary operations for sealing the aluminum bag **300** in accordance with embodiments of the present invention. The aluminum bag **300** is mechanically placed over the cassette **100** such that the aluminum bag generally tightly adheres to the external form of the cassette **100**. A border of the aluminum bag **300** is molded and sealed to enclose the cassette **100**. In accordance with embodiments of the present invention, a vacuum is not used to cause the aluminum bag to adhere to the cassette **100**. Instead, the aluminum bag **300** is mechanically shaped and molded using the external form of the cassette **100** as a guide such that at least a portion of the aluminum bag substantially conforms to at least a portion of the external form of the cassette **100** to cause the aluminum bag **300** to adhere to the cassette **100**.

A method for packing wafers in which a cassette that is sealed by a polypropylene bag is put into an aluminum bag **300** and a vacuum is applied to cause the aluminum bag to adhere to the external form of the cassette is generally known. In accordance with embodiments of the present invention, however, a vacuum is not necessary because the aluminum bag **300** may be caused to adhere to the external form of the cassette **100** through mechanical shaping and molding.

FIG. 4 illustrates exemplary operations for cutting or trimming excess material from the border **301** of the aluminum bag **300** that does not substantially conform to at least a portion of the external form of the cassette **100**. As described above, the aluminum bag **300** is mechanically shaped to generally tightly adhere to the external form of the cassette **100** and then molded. Excess material from the border **301** may then be sleekly cut using, for example, a tight cut procedure as described hereinabove. As shown in **FIG. 4**, the border **301** of the sealed portion is removed. But, in accordance with other embodiments of the present invention, unnecessary borders associated with other edges of the aluminum bag **300** may also be cut and removed depending on the particular form of the aluminum bag **300**.

As a result, the aluminum bag **300** may generally tightly adhere to the packed cassette **100**, which contains the wafer(s) **105**, and may protect the cassette **100** and wafer(s) **105** from contamination and/or degradation during transport and/or storage.

In particular, surface degradation on the wafer(s) **105** may be inhibited when the wafer(s) **105** carried in the packed cassette **100** are kept for long periods of about 45 days.

In particular embodiments of the present invention, the operations described above, such as putting the cassette **100** into the polypropylene bag **200**, sealing the polypropylene bag **200**, putting the cassette **100** into the aluminum bag **300**, and sealing the aluminum bag **300**, may be performed in a packing room on the same level as a cleaning room used in manufacturing semiconductor devices. Moreover, these operations may be performed after a final cleaning process of the wafers.

To test the effectiveness of embodiments of the present invention, the surface of a wafer was inspected after having been packed and stored for an extended time period. The degree of degradation on the surface of a wafer may vary based on the method in which the wafer was packed. Experiments were performed in which aspects of packing methods according to embodiments of the present invention were combined with vacuum sealing. Four different experimental conditions, A, B, C, and D were defined as follows:

Condition A means that vacuum sealing was used and tight cut procedures were performed when the packing bag was molded, sealed, and completed. That is, the cassette was initially packed into a polypropylene bag and then packed into an aluminum outer packing bag. The aluminum bag was sealed using a vacuum and the border of the aluminum bag was sleekly cut using tight cut procedures described above.

Condition B means that vacuum sealing was used and tight cut procedures were not performed when the packing bag was molded, sealed, and completed. That is, the aluminum bag was molded using the vacuum and an excess portion of the aluminum bag border was not sleekly cut and, therefore, remained.

Condition C means that vacuum sealing was not used and tight cut procedures were performed when the packing bag was molded, sealed, and completed. That is, condition C corresponds generally to the embodiments of the present invention described hereinabove.

Condition D means that vacuum sealing was not used and tight cut procedures were not performed when the packing bag was molded, sealed, and completed.

At least two samples were prepared in accordance with each of the four conditions. The samples were prepared by a wafer vendor and transferred to an office. For each condition, one of the samples was kept in the office and the other sample was sent to the wafer vendor and kept by the wafer vendor. It is assumed that a transferring ship was used to transfer the samples to the wafer vendor. A 45 day storage period, which is typically the maximum stock period for conventional wafers, was used. That is, 45 days elapsed from the day that the samples were packed to the day that the samples were examined for contamination/degradation.

The experiment was repeated three times and the reliability of the results was measured. An initial degree of wafer contamination was evaluated by counting the number of particles present on the surface of the wafers. Counts were taken for the number of particles that are larger than 0.12 m and the number of particles larger than 0.2 m. The number of particles was determined using a particle counter. The results were compared with the number of particles counted before packing the wafers and the increase in the number of particles was determined. The particle counts for the wafers kept by the wafer vendor were determined at the wafer vendor's facility and the particle counts for the wafers kept at the office were determined at the office facility. The inspection facilities and conditions used in obtaining the counts were the same at the office location and the vendor's location.

The results of the particle counts are shown in Tables 1 and 2. Table 1 shows the results of the samples kept in the office and Table 2 shows the results of the samples sent to and kept by the vendor.

Table 1 Office Samples

	A		B		C		D	
Size of particles	>0.12 m	>0.2 m	>0.12 m	>0.2 m	>0.12 m	>0.2 m	>0.12 m	>0.2 m
Number of increased particles	41	22	84	50	2	18	20	9

Table 2 - Vendor Samples

	A		B		C		D	
Size of particles	>0.12 m	>0.2 m	>0.12 m	>0.2 m	>0.12 m	>0.2 m	>0.12 m	>0.2 m
Number of increased particles	10	2	49	0	1	0	77	2

As shown in Tables 1 and 2, the increase in particles is smallest for those wafers subject to condition C, which corresponds generally to embodiments of the present invention. Based on these data, condition C is more preferred than conditions A, B, and D for packing wafers and storing the packed wafers over an extended time period.

Embodiments of the present invention may be effective in inhibiting the increase in haze and/or particles on the surface of wafers when wafers are transported and/or stored for extended periods of time, such as 45 days or longer. By reducing surface degradation, the wafers can be kept for a longer period, and the balance of supply and demand for the wafers may be improved.

In concluding the detailed description, it should be noted that many variations and modifications can be made to the preferred embodiments without substantially departing from the principles of the present invention. All such variations and modifications are intended to be included herein within the scope of the present invention, as set forth in the following claims.